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FINAL

TEST OF THE QUALITY IMPROVEMENT SYSTEM FOR PROCUREMENT INSTRUMENTS

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ARMY PROCUREMENT RESEARCH OFFICE

U.S. ARMY LOGISTICS MANAGEMENT CENTER
FORT LEE, VIRGINIA 23801

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by

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Information and data contained in this document are based on input available at time of preparation. Because the results may be subject to change, this document should not be construed to represent the official position of the US Army Materiel Development & Readiness Command.

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EXECUTIVE SUMMARY

1. BACKGROUND. A reliable system to control the quality of procurement instruments and to provide useful management information regarding document quality is needed within the Army Materiel Development and Readiness Command (DARCOM). Therefore, the Army Procurement Research Office (APRO) was tasked to develop and test a quality improvement system for procurement instruments that satisfies both requirements. A previous APRO report (613-1) presented the initial system design; this final report covers the test findings and resulting recommendations.

2. STUDY OBJECTIVES. The objectives of this study are to develop and test a system that (i) aids in the improvement and control of the quality of DARCOM procurement instruments and (ii) provides useful management information compatible with the DARCOM procurement management program.

3. STUDY APPROACH. The approach taken to achieve these objectives includes the identification and evaluation of quality indicators, a review and analysis of existing software quality control systems and techniques, interviews with procurement personnel, and the synthesis and test of a system that meets DARCOM's requirements.

4. CONCLUSIONS AND RECOMMENDATIONS. The Quality Improvement System for Procurement Instruments (QISPI) as described in this and the previous QISPI report has considerable potential as a statistical tool for procurement management to control the quality of their procurement instruments. Both simulation and application tests have shown the system structure and procedures to be feasible in an operating environment. Consideration should be given to implementing QISPI, or selected segments thereof, at the Commodity Commands.

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CHAPTER I

INTRODUCTION

A. BACKGROUND

Because the commodity commands within the US Army Materiel Development and Readiness Command (DARCOM) are concerned about the quality of their procurements, the Army Procurement Research Office (APRO) was tasked to develop and test a quality control system for procurement instruments. The system was both to aid in the improvement and control of DARCOM procurement instrument quality and to provide useful management information compatible with the DARCOM procurement management program. An earlier APRO report titled "Quality Improvement System for Procurement Instruments" (QISPI) presented details of the initial development effort of such a system.[1] This report continues the description of the QISPI development effort and includes the system test results and implementation recommendations. System modifications based upon test findings are also presented.

A familiarity with the previous QISPI report is assumed in many areas of this report. Therefore, the reader will find it helpful to review 613-1 before reading further. This is particularly necessary to understand what procurement instrument quality indicators are and what deficiencies are recorded against these indicators.

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[1] Norton, M. G. "Quality Improvement System for Procurement Instruments," Army Procurement Research Office, Fort Lee, Virginia 23801. APRO 613-1, February 1977.

The system structure as previously designed is briefly reviewed in the remainder of this chapter. Chapter II describes the system tests conducted at two DARCOM commodity commands. A discussion of test findings and other quality control considerations is presented in Chapter III. Chapter IV gives the study conclusions and implementation recommendations.

B. REVIEW OF QISPI

1. Operation of QISPI.

Document quality measurement and control begins at the commodity command level with a quality indicator (QI) calculation based upon the number and type of instrument deficiencies per page. These deficiencies or errors are detected through formal board review. Standard control charts for QI are used to determine document acceptability and track quality levels at the commodity commands. Corrective action is taken where needed according to the information provided by QISPI.

The QI values from each commodity command are adjusted at the HQ DARCOM level to reflect review board proficiency and sampling percentages which results in the final performance indicator (PI) calculation for all of DARCOM. This PI is a measure of outgoing instrument quality.

2. Quality Indicator.

The quality indicator (QI) used in QISPI to gauge instrument quality is the number and type of deficiencies detected during review by a procurement review board. The exact expression for QI which is calculated for each instrument at the commodity command level is given in equation (1).

$$QI = \frac{\sum_{i=1}^{n} B_i + C \cdot \sum_{i=1}^{n} A_i}{n} \qquad (1)$$

where:

QI is the weighted number of deficiencies/page,

B is the number of minor deficiencies,

A is the number of major deficiencies,

C is the weighting constant,

n is the number of instrument pages.

Depending upon the actual deficiency rates and sample size; i.e., number of document pages, the probability distribution function of the QI is well described by either the chi-square distribution or normal distribution. Chapter III discusses which is more appropriate and when.

Once these QI values are calculated, they are plotted on standard quality control charts either individually or as group averages. The control charts are then used to determine instrument acceptability and indicate quality trends.

3. Performance Indicator.

To account for both instrument sampling and deficiencies that go undetected during instrument preparation and review, a second calculation is required called the performance indicator (PI). The expression for PI is given in equation (2).

$$PI = \frac{(NLI)(\frac{QIL}{PF} - QIL) + (NSI)(\frac{QIS}{PF} - (QIS)(SF))}{NLI + NSI} \qquad (2)$$

where:

PI is the performance indicator in deficiencies/page,

NLI is the number of instruments prepared and reviewed 100 percent,

QIL is the average QI of the 100 percent reviewed instruments,

PF is the proficiency factor ($0 < PF \leq 1.0$),

NSI is the number of instruments prepared in the group which was sample reviewed,

QIS is the average QI of the sample reviewed,

SF is the sampling factor ($0 < SF \leq 1.0$).

Whereas the QI value is essentially a measure of incoming quality, the PI value becomes a measure of outgoing quality. The PI values are normally distributed by the Central Limit Theorem since average QI values are used in the calculations.

Because solicitation and contract documents do not appear to be statistically similar enough, a separation into two groups was necessary for application in DARCOM. The expression for this commodity command PI is given in equation (3).

$$PI = \frac{(NLC)(\frac{QLC}{PFC} - QLC) + (NSC)(\frac{QSC}{PFC} - QSC \cdot SFC) + (NLS)(\frac{QLS}{PFS} - QLS) + (NSS)(\frac{QSS}{PFS} - QSS \cdot SFS)}{NLC + NSC + NLS + NSS} \qquad (3)$$

where:

PI is the performance indicator in deficiencies/page,

PFC is the review board proficiency factor for contracts,

PFS is the review board proficiency factor for solicitations for each command

NLC is the number of large dollar value contracts reviewed,

QLC is the average QI for the large dollar value contracts

NSC is the number of small dollar value contracts prepared for award

QSC is the average QI of the small dollar value contracts reviewed

SFC is the percentage of NSC that were reviewed before award

NLS is the number of large dollar value solicitations reviewed

QLS is the average QI for the large dollar value solicitations

NSS is the number of small dollar value solicitations prepared for issuance

QSS is the average QI of the small dollar value solicitations reviewed

SFS is the percentage of NSS that were reviewed before issuance.

This calculation is made at the headquarters level from data provided by the commodity commands as part of DARCOM's procurement management program.

Once the PI values are calculated, they are weighted by the applicable number of instruments for each command and averaged for the DARCOM PI measurement using equation (4).

$$PI_D = \frac{\sum_{i=1}^{m} (PI_i)(N_i)}{\sum_{i=1}^{m} N_i} \qquad (4)$$

where:

PI_D is the DARCOM Performance Indicator

N_i is the total number of instruments processed by the respective commands during the reporting period; (i.e., NLS+NSC+NLS+NSS)

m is the number of commodity commands reporting.

The commodity command and DARCOM PI values are compared with previously established targets of that commodity command to determine if the quality levels are acceptable.

The tests conducted of this system at two commodity commands are described in Chapter II.

CHAPTER II

SYSTEM TESTS

The purpose of the test applications was to determine whether or not the system procedures and development assumptions are reasonable considering the operating environment at the commodity commands. The simulation tests described in the previous APRO report have shown the QISPI mathematical structure to be feasible. The application tests described here show the proposed QISPI procedures to be workable after some minor modifications.

A. TEST PROCEDURES

The same general test plan was followed at both commodity commands. Briefly, each individual preparing a procurement instrument exceeding $200,000 in value checked the appropriate column on a Procurement Quality Checklist (shown in Figure 1) and placed the checklist in the contract file. A $200,000 threshold was used for test instruments instead of the usual $100,000 review threshold because of the limited time and resources available at both commands. During instrument review a review board member completed the remaining columns on the checklist by recording both the number of major and minor errors detected and the number of document pages. A slightly expanded version of the error definitions used is provided in Appendix A. The instrument and file were returned to the preparer after review for any necessary corrective actions; the checklist was filed for APRO's later use.

The process at the DARCOM commodity commands by which the

reviewers conduct instrument reviews can be illustrated by briefly examining line 9, for example, of the checklist in Figure 1. The type of questions that must be answered to determine whether the instrument is acceptable regarding the negotiation authority include the following:

1. Is a negotiation authority appropriate for this procurement?
2. If not appropriate, was it incorrectly included?
3. If appropriate, is it cited correctly?
4. If appropriate, is there sufficient justification in the contract file for its use?

If these questions are not answered satisfactorily in the instrument or file, an error is charged and recorded on the checklist in either the major or minor column as appropriate.

Performance data was not plotted on control charts because of the short test periods - four months at one command and two months at the other. Also, no interaction was made with HQ DARCOM as described in the previous APRO report since the test concerned only the commodity command operations.

Although the test procedure was basically the same at both commands, the environment at each differed in some important ways. This provided a good opportunity to judge the system with minor variations of the same procedure.

The first command operates with a permanent, full-time review board. Contract and solicitation documents exceeding the established dollar threshold were subjected to a thorough and detailed review by an individual board member prior to the board meeting. For test purposes, errors detected by

PROCUREMENT QUALITY CHECKLIST			Annotated Elements Are Correct			
			Contracting Specialist/ Officer		Reviewing Official NO (Error Type & Number)	
Contract/Solicitation No.	Modification/Amendment No.	PR/Project No.	YES	N/A	MAJOR	MINOR

	YES	N/A	MAJOR	MINOR
SECTION A	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX
1. Type of Contract, Modification, Solicitation, Amendment, & Codes		XXXXXXXX		
2. Contract, Modification, Solicitation, Amendment Numbers		XXXXXXXX		
3. Issuing, Administrative and Paying Offices and Codes		XXXXXXXX		
4. Delivery Discount, and Invoice Information		XXXXXXXX		
5. Contractor Name, Address and Code				
6. Ship to/Mark for and Codes		XXXXXXXX		
7. Accounting and Appropriation Data, certified and available				
8. Contract/Modification Amount, Prices and Justification				
9. Negotiation Authority, Included and Appropriate				
10. All Other Section A Elements e.g. Sole Source, SB Review, DO Rating, etc.				
SECTION B	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
11. Government Contract/Solicitation Forms included with appropriate date, etc.				
12. Contractor's Representations, Certifications and Statements completed				
SECTION C	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
13. Instructions, Conditions and Notices included and appropriate				
SECTION D	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
14. Evaluation Factors, e.g. Discount, Gov't Property, Transportation, etc.				
15. Factors Other Than Price and Relative Order of Importance				
16. All Other Section D Elements				
SECTION E	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
17. Line and Subline Item Nos./NSN/Part Nos.				
18. Nouns and Quantities				
19. All Other Section E Elements				
SECTION F	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
20. Description and Specification, Including Revisions and Dates				
21. Brand Name or Equal Statement				
22. All Other Section F Elements				
SECTION G	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
23. Preservation, Packaging, Packing and Marking				
SECTION H	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
24. Delivery or Performance Dates and Place and Method of delivery				
SECTION I	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
25. Inspection and Acceptance Requirements				
26. All Other Section I Elements				
SECTION J	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
27. Special Provisions, e.g. Option, Warranties, First Article, etc.				
SECTION K	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
28. Paying and ACO Instructions Including PCO Information				
29. All Other Section K Elements				
SECTION L	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
30. Required General Provisions				
31. Additional Applicable General Provisions				
32. Appropriate Alterations to General Provisions				
SECTION M	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
33. List of All Documents, Exhibits, Attachments				
34. Forms, Numbers, Names, Dates, and Number of Pages				
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX
35. TOTAL NUMBER OF DEFICIENCIES	XXXXXXX	XXXXXXXX		
36. TOTAL NUMBER OF DOCUMENT PAGES	XXXXXXX	XXXXXXXX		
37. QUALITY INDICATOR (QI)	XXXXXXX	XXXXXXXX		

Contract Specialist (Signature & Date)	Contracting Officer (Signature & Date)	Reviewing Official (Sig. & Date)

FIGURE 1. Procurement Quality Checklist

legal and other reviewers both prior to and during the board meeting were also recorded on the checklists. Additionally, this command counted all pages in the instrument package except attachments. This count included section M pages which consist primarily of DD Forms 1423.

The second test command operates with an ad hoc review board. The board chairman is the only permanent member; other members are rotated from the various functional areas. Instruments exceeding the $200,000 threshold were reviewed by the board chairman prior to the board meeting, and detected errors were recorded. For test purposes, errors detected during the board meeting by other members were also recorded on the checklist. Errors found during the legal review prior to the board meeting were not recorded on the checklist. The second command excluded the section M pages and attachments from the total page count.

B. TEST RESULTS

QI scores obtained from the test applications were calculated using equation (1) with the weighting constant arbitrarily set equal to four. Frequency histograms of the resulting QI values are shown in Figures 2 and 3.

Figure 2 shows the QI scores for both contract and modification documents for Command A which uses a permanent, full-time review group. Test data for five solicitations is excluded from this figure because contracts and solicitations are not statistically similar enough to be treated the same. The QI scores for the small sample of solicitations averaged 1.78 weighted deficiencies per page; the number of pages averaged 65. The average major and minor error rates for Command A were .118 and .147 deficiencies per page respectively.

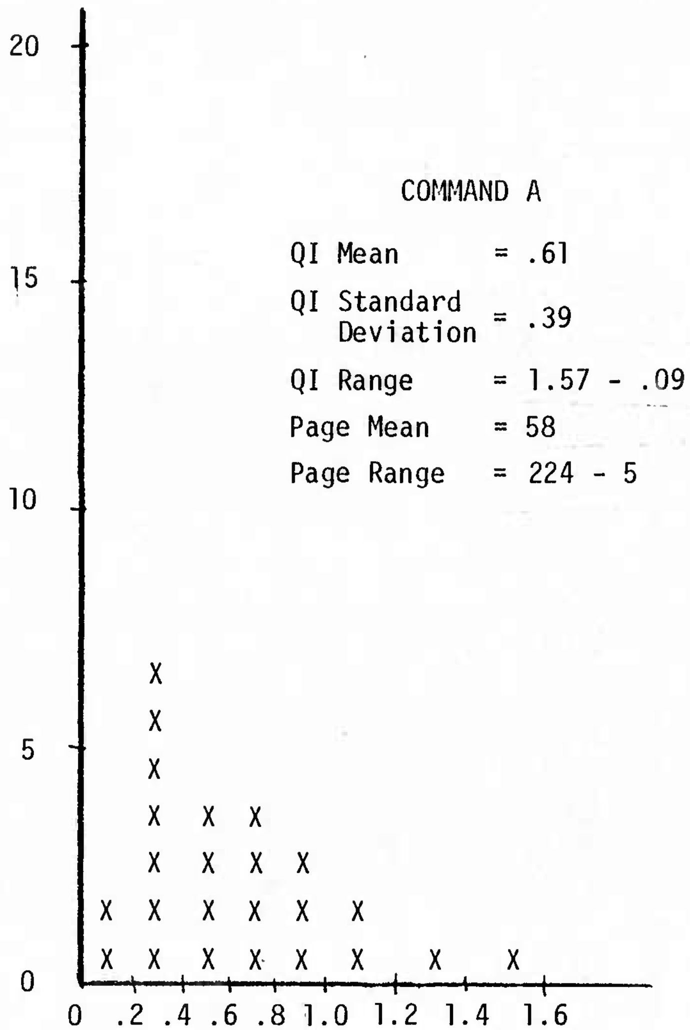

FIGURE 2. Command A Frequency Distribution of QI Values

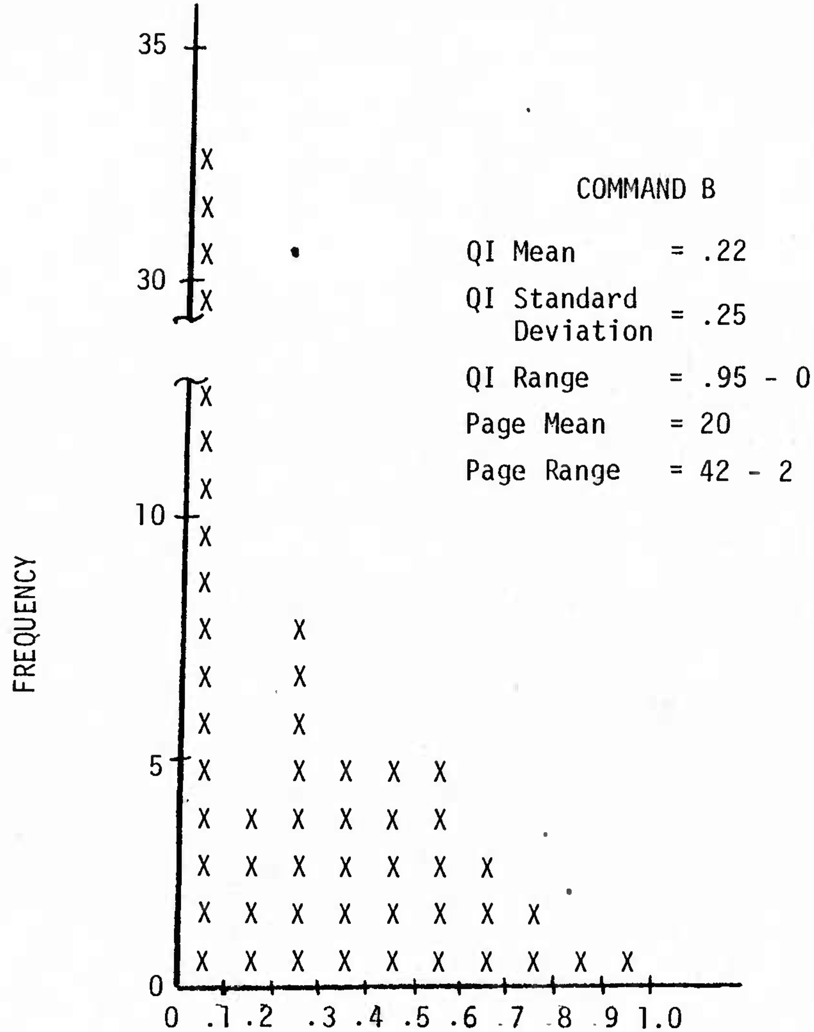

FIGURE 3. Command B Frequency Distribution of QI Values

Figure 3 for Command B shows scores for contract documents only. Contract modifications were excluded because their small number of pages caused highly erratic fluctuations in QI scores. Command B, which operates with an ad hoc review board, had average major and minor error rates of .049 and .027 deficiencies per page respectively.

Figures 2 and 3 also show the considerable difference in the mean and range values for number of instrument pages that resulted from the different command approaches to page count.

The application test data supports the assumptions made during system development regarding error rates and distributions. Although the test data is somewhat limited, it shows that the chi-square and normal probability distributions are reasonable over the expected range of instrument pages and error rates. The selection of the individual page as the unit of measurement over the individual document is also appropriate judging from the test data.

In addition to QI scores and error rates, the test applications provided a better understanding of the system's potential usefulness. QISPI appears to be more useful for management information and control than as an aid for the procurement contracting officers (PCOs) who are responsible for instrument preparation. Mixed comments were received from those who completed the test checklists. Some thought it was helpful, but others did not. The possible regard of QISPI by operating personnel as a grading or rating system naturally produced a negative feeling in some.

Management personnel at the test commands indicated that QISPI could be a good management tool. The information it provides would be useful in improving and controlling the quality level of their procurement instruments;

however, they did express extreme concern about the use of the command's quality information at HQ DARCOM level. They felt that quality comparisons might be made between commands without a complete understanding of the procedural differences between commands. This concern is warranted since meaningful comparisons are possible only if the instrument preparation and review procedures are the same, and they currently are not.

It took less than 15 minutes extra each during instrument preparation and review to complete the checklist for the test. Since the checklist serves to organize, guide and record the work already being done, little additional effort was required. Some duplication of effort during the test period was necessary because both commands have their own document and file checklists and already record some errors in the form of board minutes. If QISPI is implemented at the commands and the checklists and error recording procedures are standardized, no duplication of effort will exist.

Chapter III discusses how these application tests have impacted the initial system design and operating procedures.

CHAPTER III

DISCUSSION OF FINDINGS

A. TEST APPLICATIONS

A number of observations can be made from the test applications and resulting test data. First, the skewness evident in Figures 2 and 3 suggests that the QI scores are better described by the chi-square probability distribution for instruments with few pages and low error rates. The normal approximation adequately describes all other instrument QI values. The general expressions for the expected value and variance of the QI distribution are given in equations (5) and (6) respectively.[2]

$$EV(QI) = L1 + C \cdot L2 \tag{5}$$

and

$$Var\ (QI) = \frac{1}{N}(L1 + C^2 \cdot L2) \tag{6}$$

where

L1 is the minor error rate in deficiencies per page,

L2 is the major error rate in deficiencies per page,

C is the weighting constant and

N is the number of document pages.

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[2]Solomon, Herbert. Unpublished memo regarding the QI distribution. Stanford University, Stanford, California 94305. 15 Oct 76.

The QI expressed in equation (1) for any document of N pages is a linear combination of two independent Poisson variables. The distribution parameters given above reflect this.

The point beyond which the normal distribution is a good approximation is not firm but can be estimated for specific error rates using simulation and equations (5) and (6). Figures 4 and 5 show the results of simulating 1000 instruments with the error rates obtained during the tests; i.e., major and minor error rates equal to .12 and .15 respectively for Command A and .05 and .03 respectively for Command B. Normality is reached around 50 pages per document as shown in Figure 4 for Command A error rates and around 90 pages per document as shown in Figure 5 for Command B error rates. Chi-square goodness of fit tests for normality support the normal approximation for these points. Once the major error rate falls below about .01 deficiencies per page, the chi-square distribution is best used for all instruments regardless of number of pages. Control charts or tables developed for operating personnel must be structured accordingly.

The standard quality control chart approach originally planned for tracking quality and determining acceptable performance may need to be modified slightly to minimize chart maintenance and tracking effort. Control limits for QI control charts are dependent upon the variance of QI which is a function of the number of pages in the instrument. The wide range in number of pages encountered during the test prohibits approximation with just one or two sets of limits with any reasonable degree of accuracy. Although separate limits would not be needed for each document page number, a minimum of five limits grouped as follows would be required to keep the variance approximately constant within each group.

Figure 4

FREQUENCY DISTRIBUTION OF
PROCUREMENT INSTRUMENT DEFICIENCIES PER PAGE (QT)

HISTOGRAM OF VARIABLE 1
MIN = 0.079999 MAX = 1.600000

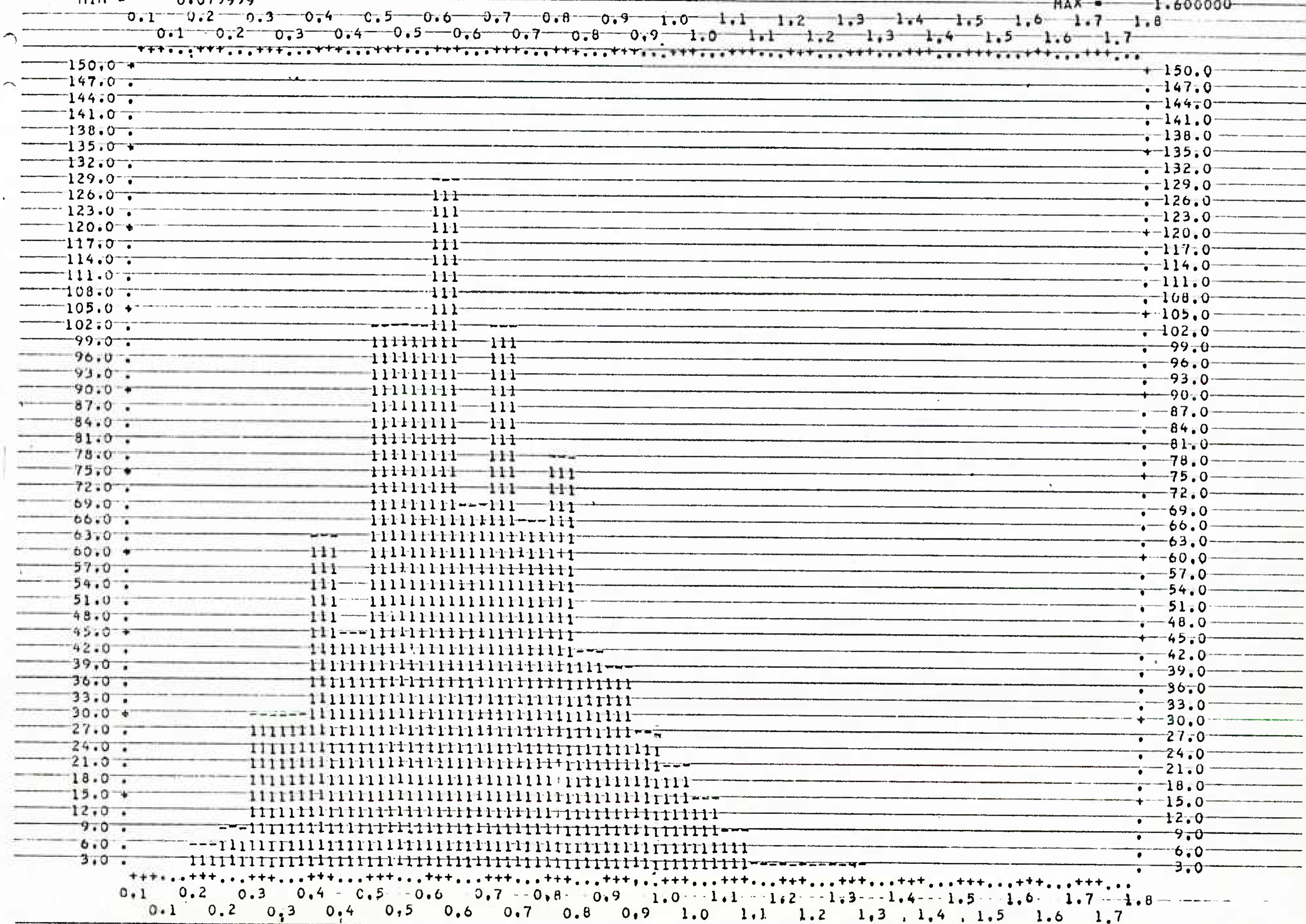
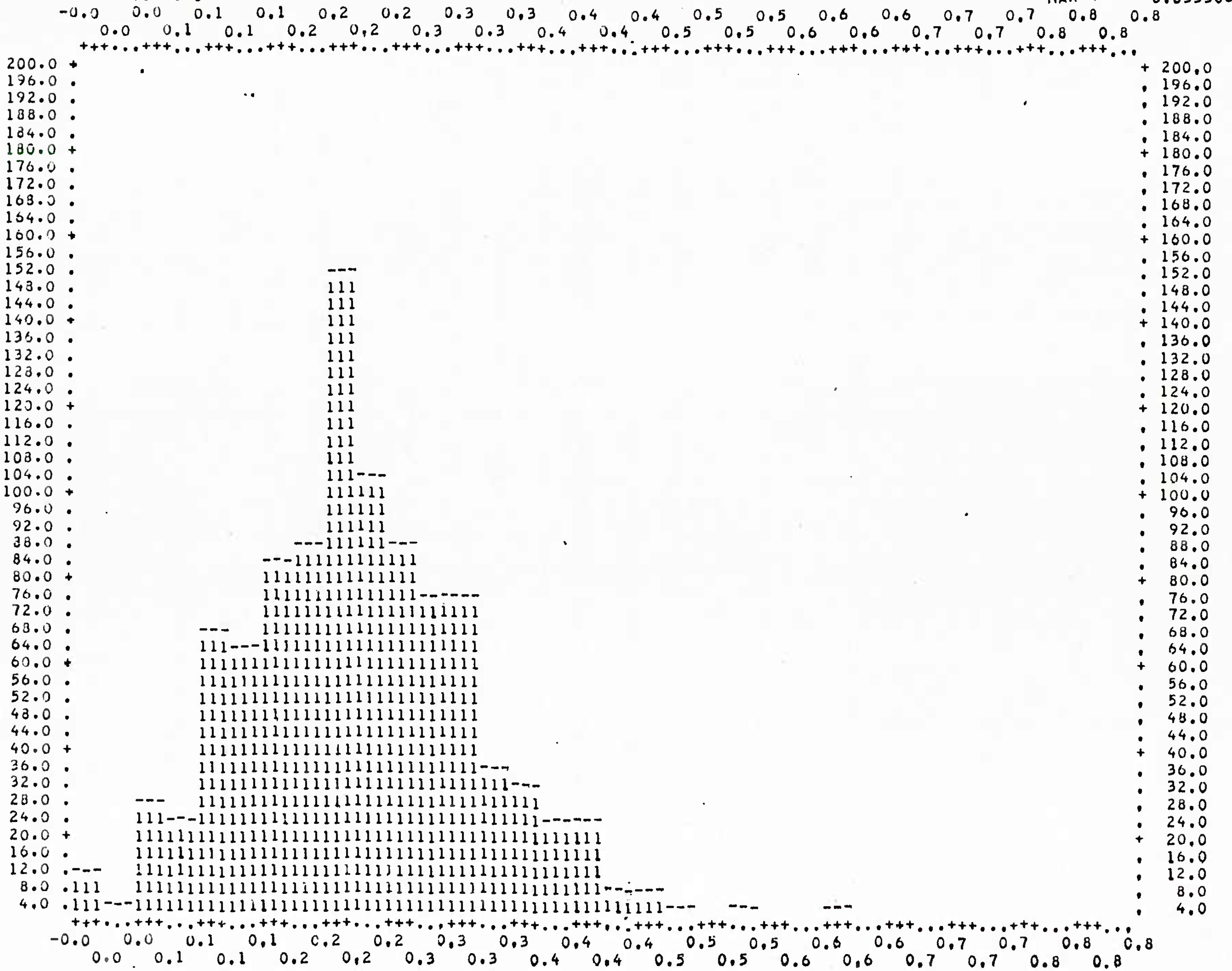


Figure 5

FREQUENCY DISTRIBUTION OF
PRUCUREMENT INSTRU ENT DEFICIENCIES PER PAGE (QI)

HISTOGRAM OF VARIABLE 1
MIN = -0.000000 MAX = 0.633300



Group 1: 5-10 pages

Group 2: 11-30 pages

Group 3: 31-60 pages

Group 4: 61-100 pages

Group 5: > 100 pages

Additionally, the chi-square distribution applies to a substantial portion of the procurement instruments, and this complicates the use of standard control charts. Upper and lower control limits are not as easily calculated for the chi-square as for the normal distribution. And as quality levels improve over time, the error rates will decrease causing an even greater skewness and chi-square applicability.

This complication in determining acceptable performance is easily overcome by developing tables of acceptable error values. Figure 6 shows a sample page from such a table generated by APRO. The table presents the upper and lower error values that correspond to the upper and lower 5% points of its distribution for given error rates and page numbers. L1 is the minor error rate and L2 is the major error rate. If the total weighted number of errors for an instrument falls outside the table values, assignable causes of variation are present and should be investigated.

Acceptance tables identify out-of-control points, but used alone do not provide the quality tracking feature that charts do. It will be necessary to either construct five separate charts for each of the four instrument groups or combine charts by putting more than one set of upper and lower control limits on some. Figures 7 and 8 illustrate the two different approaches. Control limits in Figure 7 are for a document in one page range, say 61 to 100 pages. The outer set of control limits in Figure 8 is for a document in

NUMBER OF PAGES = 31 TABLE OF UPPER AND LOWER ACCEPTABLE K VALUES (K .GE. QI*N)

L1//L2	.010	.020	.030	.040	.050	.060	.070	.080	.090	.100	.110	.120	.130	.140	.150	.160	.170	.180	.190	.200
0.010	5	9	12	13	16	17	20	21	24	25	28	28	32	32	33	36	37	40	40	44
	0	0	0	0	0	0	0	0	0	3	3	3	3	3	4	7	7	7	7	8
0.020	6	9	12	13	16	18	20	21	24	25	28	29	32	33	34	36	37	40	41	44
	0	0	0	0	0	0	0	0	0	3	3	3	3	4	5	7	7	7	8	9
0.030	7	9	12	14	17	18	21	22	24	26	28	29	32	33	35	37	38	40	41	44
	0	0	0	0	0	0	0	0	1	3	3	3	4	4	5	7	7	8	8	9
0.040	7	10	13	14	17	19	21	22	25	26	28	30	32	33	35	37	38	40	42	44
	0	0	0	0	0	0	0	0	1	3	3	3	4	5	6	7	7	8	8	10
0.050	8	10	13	15	17	19	21	23	25	27	29	30	32	34	36	37	39	41	42	44
	0	0	0	0	0	0	0	1	2	3	3	4	4	5	6	7	8	8	9	10
0.060	8	11	13	15	18	20	21	23	25	27	29	30	33	34	36	38	39	41	42	44
	0	0	0	0	0	0	0	1	2	3	3	4	5	5	7	7	8	8	9	11
0.070	9	11	14	16	18	20	22	24	26	27	29	31	33	34	36	38	40	41	43	45
	0	0	0	0	0	0	1	1	2	3	4	4	5	6	7	8	8	9	10	11
0.080	9	11	14	16	18	20	22	24	26	28	30	31	33	35	37	38	40	42	43	45
	0	0	0	0	0	1	1	2	3	3	4	5	5	6	7	8	8	9	10	11
0.090	9	12	14	16	19	21	23	24	26	28	30	32	33	35	37	39	40	42	44	45
	0	0	0	0	1	1	1	2	3	4	4	5	5	6	7	8	9	9	10	11
0.100	10	12	15	17	19	21	23	25	27	28	30	32	34	35	37	39	41	42	44	46
	0	0	0	0	1	1	2	2	3	4	4	5	6	7	8	8	9	10	11	12
0.110	10	13	15	17	19	21	23	25	27	29	31	32	34	36	38	39	41	43	44	46
	0	0	0	1	1	1	2	3	3	4	5	5	6	7	8	8	9	10	11	12
0.120	10	13	15	18	20	22	24	25	27	29	31	33	34	36	38	40	41	43	45	46
	0	0	1	1	1	2	2	3	4	4	5	6	6	7	8	9	9	10	11	12
0.130	11	13	16	18	20	22	24	26	28	29	31	33	35	36	38	40	42	43	45	47
	0	1	1	1	2	2	3	3	4	5	5	6	7	7	8	9	10	11	11	12
0.140	11	14	16	18	20	22	24	26	28	30	32	33	35	37	39	40	42	44	45	47
	0	1	1	1	2	2	3	3	4	5	6	6	7	8	9	9	10	11	12	13
0.150	12	14	16	19	21	23	25	26	28	30	32	34	35	37	39	41	42	44	46	47
	1	1	1	2	2	3	3	4	4	5	6	6	7	8	9	10	10	11	12	13
0.160	12	15	17	19	21	23	25	27	29	30	32	34	36	38	39	41	43	44	46	48
	1	1	1	2	2	3	3	4	5	5	6	7	7	8	9	10	11	11	12	13
0.170	12	15	17	19	21	23	25	27	29	31	33	34	36	38	40	41	43	45	46	48
	1	1	2	2	3	3	4	4	5	6	6	7	8	9	9	10	11	12	13	13
0.180	13	15	18	20	22	24	26	28	29	31	33	35	36	38	40	42	43	45	47	48
	1	2	2	2	3	3	4	5	5	6	7	7	8	9	10	10	11	12	13	14
0.190	13	16	18	20	22	24	26	28	30	32	33	35	37	39	40	42	44	45	47	49
	1	2	2	3	3	4	4	5	5	6	7	8	8	9	10	11	11	12	13	14
0.200	13	16	18	20	22	24	26	28	30	32	34	35	37	39	41	42	44	46	47	49
	2	2	2	3	3	4	4	5	6	6	7	8	9	9	10	11	12	13	13	14

FIGURE 6. Sample Page From QISPI Acceptance Table

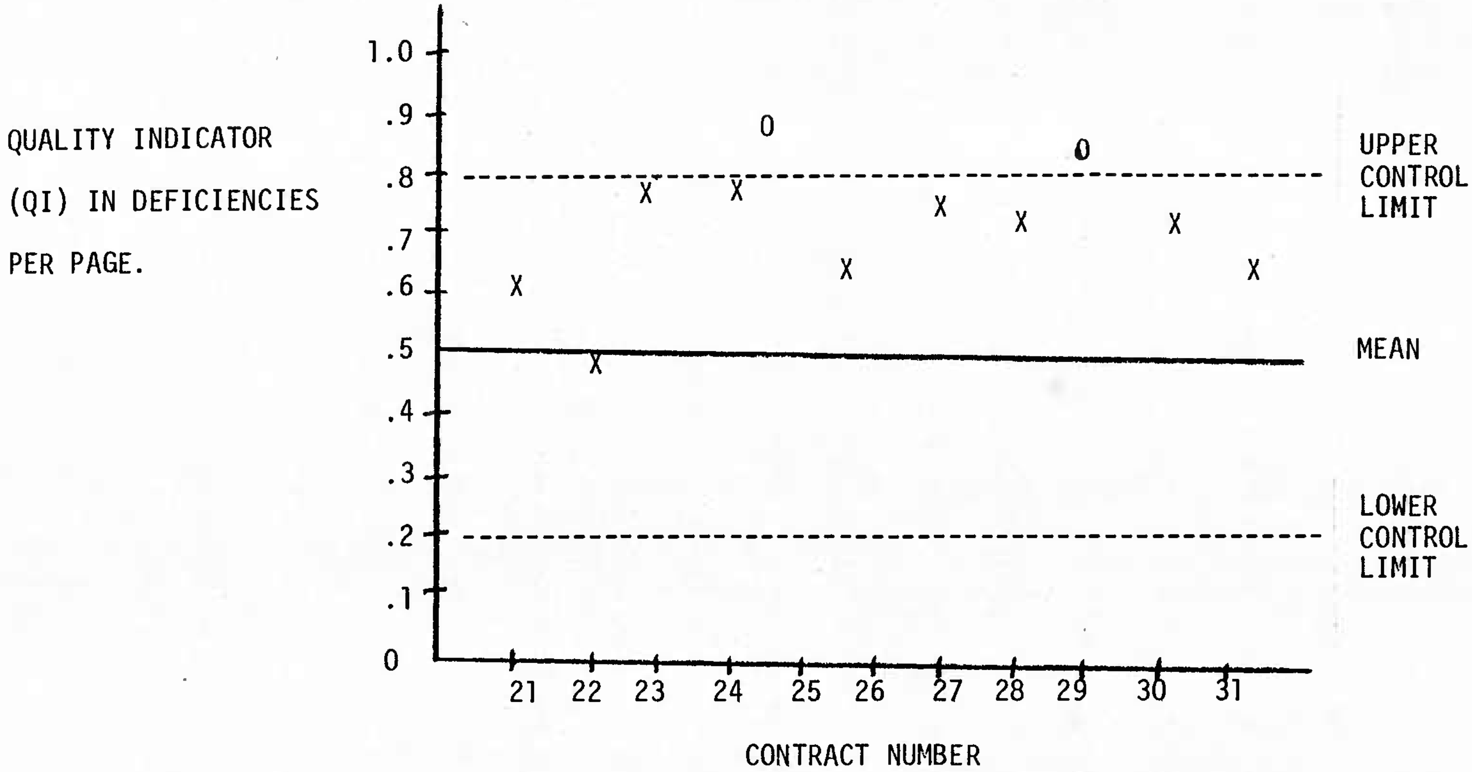


FIGURE 7. Control chart with one set of upper and lower control limits.

NOTE: X - In-control point

0 - Out-of-control point

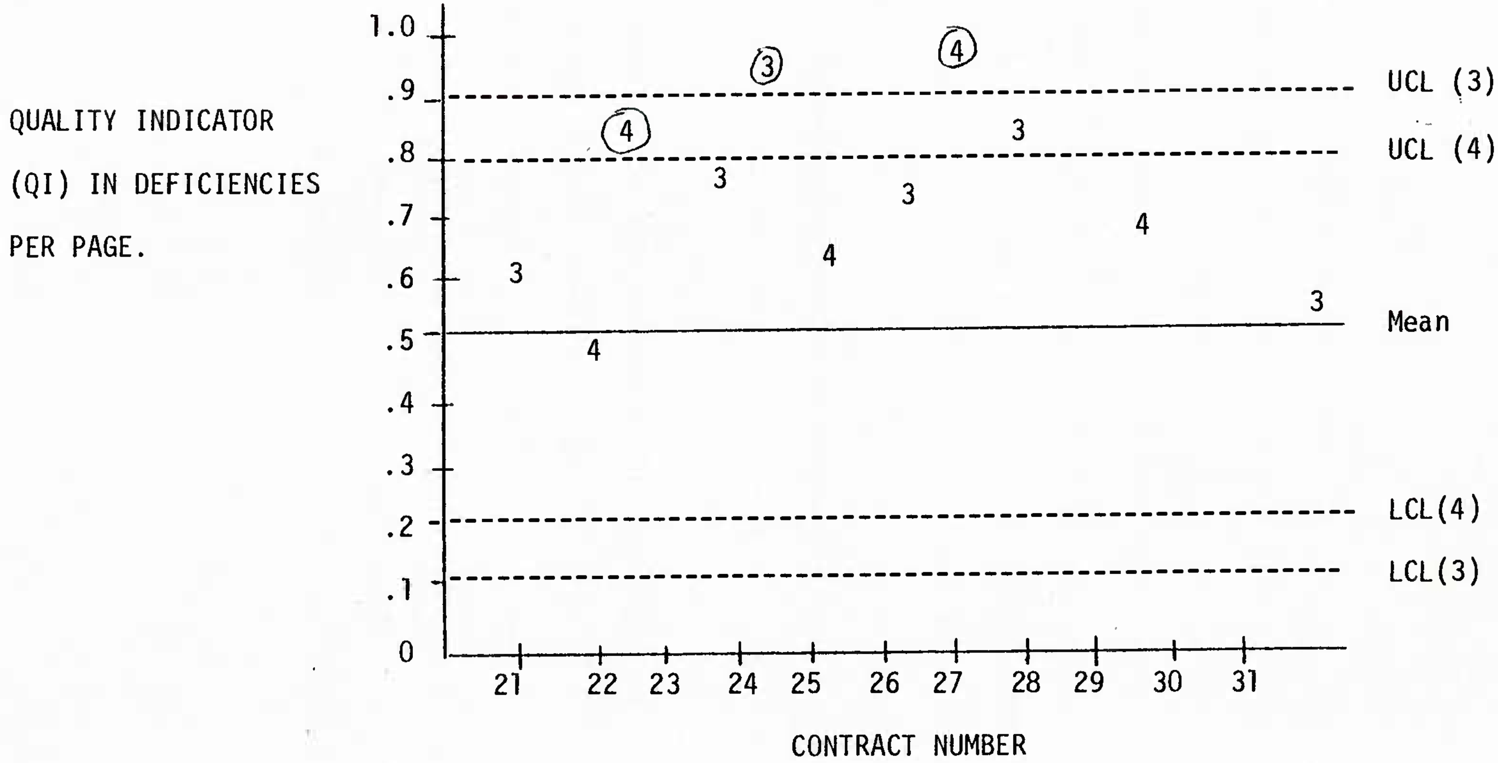


FIGURE 8. Control chart with two sets of upper and lower control limits.

NOTE: Out-of-control points are circled.

one range say 31 to 60 pages, and the inner set is for a document of a higher range say 61 to 100 pages. Out-of-control points are determined from the tables and plotted with a different symbol such as "0" shown in Figure 7 or circled as shown in Figure 8.

Instead of having five separate charts or some charts with multiple upper and lower control limits, one modified chart can be used for each instrument group but the quality trends are less clear. The only limit line on the chart is a warning line calculated for an average document of say 60 pages. This single chart approach is illustrated in Figure 9. Out-of-control points are determined from the tables and plotted with a different symbol shown as "0" in Figure 9. Quality trends, although not as readily apparent, are still discernible by the frequency of out-of-control points and clustering around the warning lines. Of course, other measures of quality can be easily calculated and also used to track performance if desired. Average QI values and percent out-of-control over a period of time are two examples of such.

The question of whether the permanent or ad hoc review board is more effective was not addressed by this test. Both have their advantages and disadvantages. The tests did show that QISPI can function under either approach. This study group favors the permanent full-time approach though, primarily because QISPI needs a thorough and consistent review to be most effective, and an ad hoc group cannot provide that as well as a permanent group can.

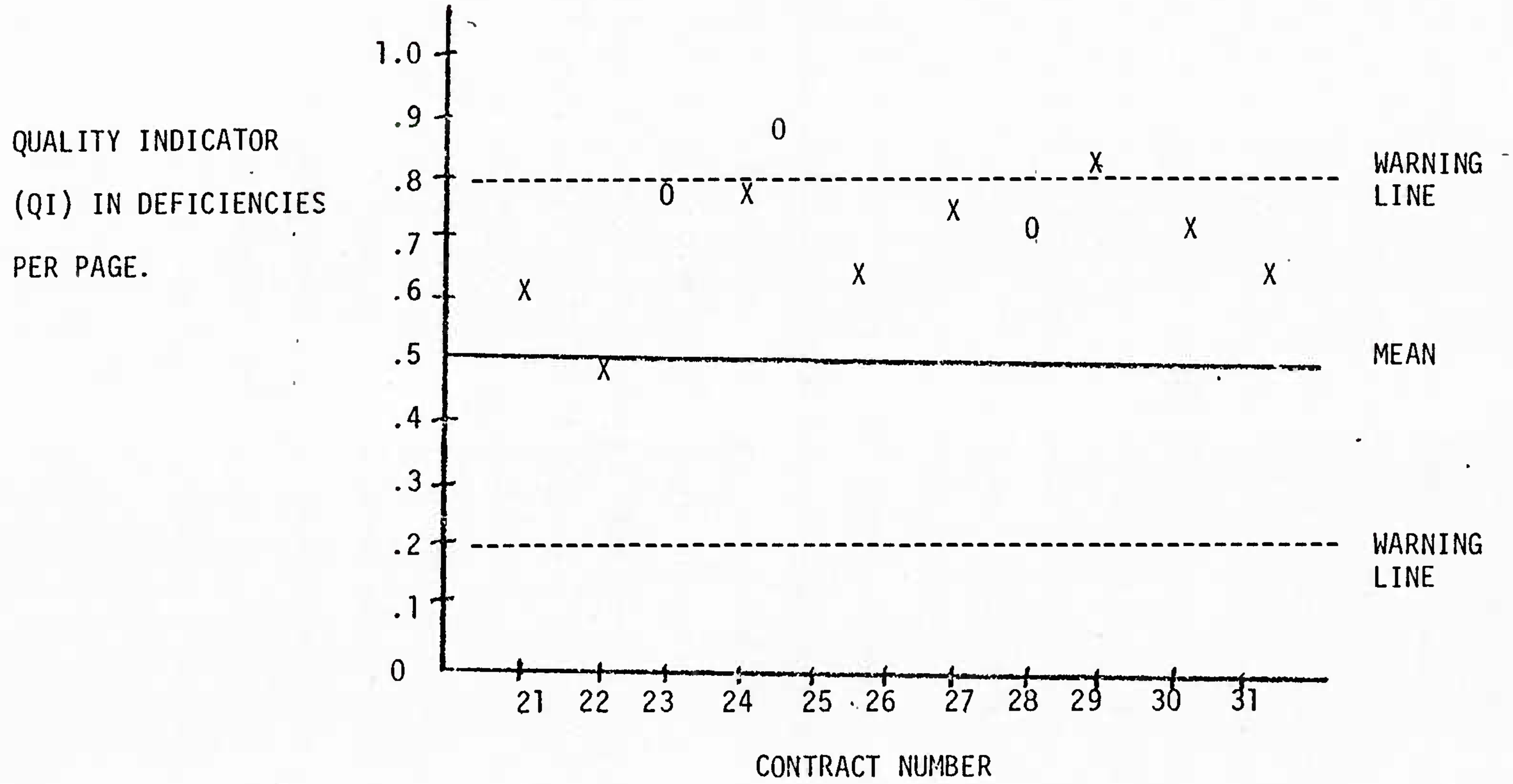


FIGURE 9. Modified control chart for contract QI.

NOTE: X - In-control point

0 - Out-of-control point

The test applications surfaced an additional question concerning the review procedure: where should procurement review and the associated error count begin in the procurement process? One test command included the legal review comments in their error count since the legal review came after package submission to the board. The other test command did not count the legal review comments except during the board meeting since the package received a legal review prior to submission to the board. Review and associated error counting should begin after the package is considered complete and ready for public release by the preparer. If legal or any other "review" is considered part of instrument preparation before submission to the formal board, comments should be excluded from the error count; otherwise, review comments should be counted.

No concensus was obtained for the value of the weighting constant for major errors. Although the value is somewhat arbitrary, it should reflect the relative criticality of the two error types regarding the degree of the potential cost or problem caused by not correcting the errors. Actually, error criticality ranges over a broad scale, and separation into just two groups was done for simplification purposes. To do otherwise would have overly complicated the system. The value of four used during the tests is satisfactory and need not be changed.

All pages except attachments can be included in the count of instrument pages. As long as these pages are reviewed by the review boards and have roughly the same probability of error as other instrument pages, including them is acceptable and increases the applicability of the normal distribution.

The QI data obtained from the test applications is adequate to establish only tentative performance targets and for just the two test commands. More realistic targets can and should be determined by experience developed over at least a six-month period at each commodity command. Judging performance against an arbitrary, unrealistic standard is self-defeating and must be avoided. This start-up period can also be used to establish the initial review board proficiency factors.

As discussed in the previous QISPI report, a thorough and consistent review is essential if QISPI is to function properly. The degree to which this is accomplished is reflected in the proficiency factors included in equations (2) and (3). Instead of having a DARCOM organization conduct periodic, independent reviews to establish these values as considered earlier, a different approach is offered here that is more objective and statistically valid.[3]

Using a controlled experiment approach, certain procurement instruments are developed in advance of board review such that some document pages have a known number of major and minor errors. After the document has been reviewed, the percentage of known errors detected gives a good estimate of the review board proficiency factors. The general expression for the resulting performance indicator; i.e., measure of outgoing quality, is given in equation (7).

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[3]Gelfand, A. E. Unpublished memo regarding software measurement error. University of Connecticut, Storrs, Connecticut 06268. March 1977.

$$PI = \frac{L1}{P1} + \frac{C \cdot L2}{P2} - QI \qquad (7)$$

where:

PI is the performance indicator in deficiencies per page,

L1 is the minor error rate in deficiencies per page,

P1 is the proficiency factor for minor errors ($0 < P1 \leq 1.0$),

C is the weighting constant,

L2 is the major error rate,

P2 is the proficiency factor for major errors ($0 < P2 \leq 1.0$), and

QI is the quality indicator in deficiencies per page.

Incorporating these provisions in equation (3) provides for more accurate estimates of commodity command performance. Equation (8) gives the expanded version of equation (3).

$$PI = \frac{(NLC)(\frac{L1LC}{P1LC} + \frac{C \cdot L2LC}{P2LC} - QLC) + (NSC)(\frac{L1SC}{P1SC} + \frac{C \cdot L2SC}{P2SC} - QSC \cdot SFC) + (NLS)(\frac{L1LS}{P1LS} + \frac{C \cdot L2LS}{P2LS} - QLS) + (NSS)(\frac{L1SS}{P1SS} + \frac{C \cdot L2SS}{P2SS} - QSS \cdot SFS)}{NLC + NSC + NLS + NSS} \qquad (8)$$

where:

L1LC, L1SC, L1LS and L1SS are the respective minor error rates for large and small contracts and large and small solicitations;

P1LC, P1SC, P1LS and P1SS are the respective proficiency factors for minor errors;

L2LC, L2SC, L2LS and L2SS are the respective major error rates;

P2LC, P2SC, P2LS and P2SS are the respective proficiency factors for major errors; and all other variables are as previously defined.

This expansion introduces more accuracy into the estimate of outgoing quality at the expense of some additional calculations and possible review board resistance since few people welcome continual grading.

B. OTHER QUALITY CONTROL CONSIDERATIONS

The quality improvement system described thus far is one approach to improve and control the quality of DARCOM procurements. Other quality information sources can and should be used to complement or supplement QISPI where useful. The indirect procurement quality indicators discussed in the previous QISPI report can be reviewed from time to time for additional insight into where problems exist and where improvements can be made. Feedback from the contract administration organizations will identify problem areas for corrective action. Comments from reviewing organizations such as the Inspector General or Procurement Management Review may also identify areas where changes can be made to improve procurement quality. All of these information sources are currently available to procurement managers.

Another approach to procurement quality control that is becoming more readily available is to prevent errors from occurring before the instrument gets to the review board by automating instrument generation as much as possible. Systems such as the Procurement Automated Data and Document System (PADDS)[5] being

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[5]Smith, CPT L. G. Letter, subject: Procurement Automated Data and Document System (PADDS), describing PADDS. US Army Missile Command, Redstone Arsenal, Alabama. 15 June 1976.

developed at the US Army Missile Command, Redstone Arsenal, and the Automated Contract Writing Procedure[6] being demonstrated at the Air Force Systems Command, Andrews AFB, are examples of this approach. These systems will not only minimize form errors, but also reduce the content error rate through comprehensive data editing and validation.

A modification to QISPI that has potential benefit after implementation is to reduce the review effort by sampling individual pages of the instruments. Instead of reviewing every instrument page as is currently being done, a random sample of pages is taken and thoroughly reviewed to estimate overall document quality. Various statistical sampling plans are available to give a desired level of assurance for minimum cost.

In summary, the test applications have demonstrated the feasibility of QISPI in an operating environment. A major question remaining is what is the most effective way to implement it? Chapter IV presents the recommended approach.

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[6] Meigs, CPT D. Printout from a contract writing demonstration. Air Force Systems Command, Andrews AFB, Washington, DC.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The Quality Improvement System for Procurement Instruments (QISPI) has considerable potential as a tool for DARCOM procurement managers to control the quality of their procurement instruments and, in turn, their procurements. When implemented it will provide the meaningful management information on document quality that is presently lacking in DARCOM so that corrective action can be taken where needed. Instrument quality control and improvement is at best haphazard without such information.

The system tests have shown that the mathematical structure of the QISPI is feasible. The chi-square probability distribution function is appropriate to describe the QI values of instruments with few pages and low error rates; the normal distribution adequately describes all other instruments. Application tests have shown the QISPI procedures to be adequate and useful in an actual operating environment. The expected benefits of improved instrument quality and management information far outweigh any additional administrative effort required to implement and maintain the QISPI.

Quality cannot be effectively reviewed into a procurement instrument. The follow-up action that is taken as a result of the information provided by a control system is what contributes to procurement instrument quality

in the long run. QISPI offers DARCOM procurement managers a way to capitalize on the statistical quality control techniques available today to improve and control the quality of their procurements.

B. RECOMMENDATIONS

Consideration should be given to implementing QISPI, or selected segments thereof, at the Commodity Commands. The implementation should proceed slowly at first, building more sophistication as experience and understanding are gained. The following specific recommendations are offered as guidelines for an effective implementation.

1. Restrict QISPI implementation to the commodity command level initially. Once a data base is established at each command and experience is gained, the commands can then forward meaningful quality information to HQ DARCOM for their use.

2. Begin QISPI implementation by recording and tracking errors in just those solicitations and contracts that are currently being reviewed; i.e., those instruments over $100,000 in value. Introduce sampling of lesser dollar value instruments once confidence is gained in the system.

3. Standardize the review and quality control procedures at all commodity commands by developing one common checklist and one review approach, preferably with a permanent, full-time review board. This eventual standardization is

essential before performance can realistically be compared among commands. The procurement quality checklist in Figure 1 with the associated error definitions in Appendix A is a good starting point.

4. Establish and maintain review board proficiency factors by periodically incorporating known errors into selected instruments. Of course, this effort must be conducted by an organization independent of the board if it is to provide valid estimates.

5. Use the acceptance tables (Figure 6) for determining out-of-control instruments and control charts (Figure 7) for quality tracking. If less control is needed after experience is gained and instrument quality improves, the modified charts (Figures 8 or 9) can be used. APRO will provide complete sets of tables and control limits for desired confidence levels upon request.

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3. Meigs, Dan. Printout from demonstration of the Automated Contract Writing Procedure. US Air Force Systems Command, Andrews AFB, Washington, DC.

4. Norton, M. G. "Quality Improvement System for Procurement Instruments," Army Procurement Research Office, Fort Lee, Virginia 23801. February 1977.

5. Smith, L. G. Letter dated 15 June 1976, to APRO describing the Procurement Automated Data and Documentation System. US Army Missile Command, Redstone Arsenal, Alabama 35809.

6. Solomon, Herbert. Unpublished memo regarding the QI distribution. Stanford University, Stanford, California 94305. 15 October 1976.

APPENDIX A

DEFINITION OF MAJOR/MINOR ERRORS

NOTE: In order to determine if certain line items such as 1A, 8C and 9C should be charged with an error, a thorough review of supporting documentation in the contract file must be made. For example, line item 8A, contract price, must be adequately supported by a price negotiation memorandum if no error is to be charged.

SECTION A

1.	Type of Contract/Modificaton/Solicitation/Amendment	
	A. Inappropriate type of contract	Major
	B. Code Incorrect	Minor
2.	Contract/Modification/Solicitation/Amendment Number	
	A. Number omitted	Minor
	B. Incorrect number	Minor
3.	Issuing,Administrative, Paying Offices	
	A. Information omitted	Minor
	B. Incorrect information	Minor
	C. Incorrect code	Minor
4.	Delivery,Discount and Invoice Information	
	A. Delivery/FOB Point omitted	Major
	B. Delivery/FOB Point incorrect	Major
	C. Discount omitted or incorrect (If no discount offered by Contractor, omission of "none" or "N/A" is not an error)	Major
	D. Omission of place for submission of invoices	Minor
5.	Conctractor's Name and Address	
	A. Incorrect Contractor	Major
	B. Address incorrect	Major
	C. Incorrect code	Minor
6.	Ship To/Mark For	
	A. Incorrect destination or destination omitted	Major
	B. MILSTRIP Data not consistent with that provided to the Contract Specialist or omitted	Minor
	C. Mark for information omitted or incorrect	Minor

7.	Accounting and Appropriation Data	
	A. Adequate certified funds not available	Major
	B. Accounting and Appropriation data cited incorrectly	Major
	C. Accounting and Appropriation data omitted	Major
8.	Contract/Modification Amount (Also Section E)	
	A. Contract price (unit and total, if applicable) omitted	Major
	B. Amount cited not consistent with the negotiated agreement or competitive price	Major
	C. Insufficient justification for contract amount	Major
9.	Negotiation Authority	
	A. Authority cited incorrectly	Minor
	B. No negotiation authority, if required	Major
	C. Negotiation authority not appropriate or insufficient justification for its use	Major
10.	Other Section A Elements	
	A. If sole source, omission of sole source justification or NCPSA and proper signatures/approvals	Major
	B. Omission of Small Business review	Major
	C. Omission of DO/DX Rating	Minor
SECTION B		
11.	Certifications and Representations	
	A. Required certification and Representation omitted	Minor
	B. Clause not in the latest form required by ASPR or other regulations	Minor
	C. Inappropriate provision included	Minor
12.	Contractor's Submission of Certifications and Representations	
	A. Certification and Representation not completed	Minor
SECTION C		
13.	Instructions, Conditions, Notices	
	A. Omission of pertinent information	Minor
	B. Inclusion of inappropriate information	Minor
	C. Ambiguous information	Minor
SECTION D		
14.	Evaluation Factors	
	A. Pertinent factors omitted (i.e. discount, Government Production and Research Property, F.A. testing, transportation)	Major

15.	Factors other than price	
	A. Pertinent factors omitted	Major
	B. Relative order of importance omitted or incorrect	Major
	C. Factors not consistent with Evaluation Plan	Major
	D. Evaluation weight set forth in contract	Minor
16.	Other Section D Elements	Major/Minor
	SECTION E	
17.	Line and Subline Item Number	
	A. CLIN/SUBCLIN (number) omitted	Minor
	B. CLIN/SUBCLIN (number) incorrectly identified	Minor
18.	Nomenclature, NSN, Part Number, Quantity	
	A. Omission of data	Major
	B. Incorrect Nomenclature	Major
	C. Incorrect NSN or Part Number	Major
	D. Incorrect Quantity	Major
19.	Other Section E Elements	Major/Minor
	SECTION F	
20.	Description and Specifications including Revisions and Dates	
	A. Description or Spec omitted	Major
	B. Revision/date omitted or unidentified	Major
	C. Incorrect description, specification, or revisions	Major
21.	Brand Name or Equal Statement	
	A. Statement omitted	Major
	B. Statement incorrect	Major
22.	Other Section F Elements	Major/Minor
	SECTION G	
23.	Preservation, Packaging, Packing, Marking	
	A. Information omitted or incorrect	Major
	SECTION H	
24.	Delivery or Performance	
	A. Information omitted or incorrect	Major
	B. Place and method of delivery, if FOB destination	Major
	C. Place and method of delivery, if FOB origin	Minor
	SECTION I	
25.	Inspection and Acceptance Requirements	
	A. Inspection and Acceptance point omitted or incorrect	Major

26.	Other Inspection or Acceptance Requirements (i.e. Fly-to-Buy) omitted or incorrect	Major

SECTION J

27.	Special Provisions	
	A. Option, EPA, Incentive arrangement, F.A. approval, Warranty Clause, GFP and approvals, DTC, Award Fee Provisions omitted, incorrect or ambiguous	Major
	B. Special Provisions ambiguous or inappropriate or proper approvals not obtained	Major
	C. Technical liaison clause omitted or incorrect	Minor
	D. Other Special Provisions	Major/Minor

SECTION K

28.	Paying and ACO Instructions Including PCO Information	
	A. Information omitted or incorrect	Minor
29.	Other Section K Elements	Minor

SECTION L

30.	Required General Provisions	
	A. Provision omitted or not current	Major
31.	Additional Applicable General Provisions	
	A. Provision omitted or not current	Major
32.	Appropriate Alteration to General Provisions	
	A. Alteration omitted or incorrect	Major

SECTION M

33.	List of all Documents, Exhibits, Attachments	
	A. If document, exhibits, attachments omitted but elsewhere incorporated	Minor
	B. If omitted and not incorporated elsewhere in contract	Major
34.	Form Number, Name, Date, Number of Pages	
	A. Omission of information	Minor
	B. Incorrect information	Minor

APPENDIX B

STUDY TEAM COMPOSITION

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